22. The method of Claim 15 whereby the economic life of a molding tool is extended through the use of ceramic injection molded mold inserts.

23. The method of Claim 15 whereby the simultaneous mass-production of identical, matching or interchangeable molded articles can be rapidly implemented in different geographical locations.

A1

REMARKS - General

By the above amendment, applicants have rewritten or cancelled their claims to define the invention more particularly and distinctly so as to overcome the technical rejections and define the invention patentably over the prior art.

The Rejection of Claims 13 and 14 Under 35 U.S.C. § 112

The last O.A. rejected dependent claims 13 and 14 under 35 U.S.C. § 112 on the grounds that these claims recited the limitation 'the mold article' for which there was said to be insufficient antecedent basis.

Accordingly, applicants have withdrawn claims 13 and 14 and submit that the specification now complies with § 112.

The Rejection Of Claim 1 On Amaya et al (US 5,976,457) Is Overcome

The last O.A. rejected independent claim 1 on Amaya et al (U.S. 5,976,457). Claim 1 has been rewritten as new claim 15 to define patentably over the cited reference. Applicants request reconsideration of this rejection, as now applicable to claim 15, for following reasons:

1. Applicants' invention provides a novel means for extending the life of molds and mold cavity inserts.

While recognizing and emphasizing the importance and benefits of tool longevity, and equating this criterion with superior wear resistance, Amaya et al do not pretend to provide a means to extend the life of permanent tooling or tool inserts.

The limitations of Amaya et al.'s invention are recognized in their specification, viz:

US 5,976,457, Col. 5, Lines 37-42

3-) To provide heat treatable metal dies from materials such as carbon steel, stainless steels, or other ferrous and non-ferrous materials that would last longer than the present state of the art "soft" tooling, thereby allowing greater flexibility in time and cost for the testing of prototype designs.

US 5,976,457, Col. 10, lines 44-47

Since the die sets will have been fully hardened, one of the primary advantages will be the durability of the tool to produce sample parts beyond the norm of 30-40 parts in prototype tooling.

By definition, prototype tooling is made from materials that are softer and thus require less effort to machine than permanent tooling. Amaya et al's metal injection molded mold inserts, being hardened after sintering, will inherently be more durable than soft tooling. But Amaya et al's metal injection molded mold inserts are, at best, equal in hardness to the prior art's conventionally machined and hardened mold inserts made from tool steels. This is natural since metal injection molded tool and die inserts, depending on their as-sintered density, can approach but will never surpass the hardness of conventionally

machined tool and die inserts and, like the latter, must be hardened before they can fulfill their function. Hence, molds fitted with Amaya et al's metal injection molded and hardened mold inserts will wear at substantially the same or possibly a slightly faster rate as molds equipped with mold inserts fabricated by conventional machining and hardening.

Applicants' invention provides a novel means for extending the life of molds and mold cavity inserts quasi indefinitely by injection molding mold cavity inserts from ceramic materials, the hardness of which is substantially higher than that of any hardened tool steel.

For example, the hardness of hardened tool steels and injection molded ceramic materials typically compares as follows:

M4 tool steel	HRC 64-66	HV 800-865
H13 tool steel	HRC 52-54	HV 544-577
Alumina 99.99% dense:	R45N 90	HV 1900-2050
Tungsten carbide:	R45N 80	HV 1200-1700
Partially stabilized zirconia:	R45N 80	HV 1200-1300
Zirconium toughened alumina:	R45N 85	HV 1500-1630

As a result, ceramic mold cavity inserts fabricated in accordance with the instant invention are substantially unabradable, even when used to mold abrasive ceramic injection molding feedstocks containing coarse discrete ceramic particulates. Hence, the life of tooling equipped with ceramic mold inserts fabricated according to the applicants' invention will, as a rule, outlast that of the commercial products for which they were intended.

Ceramic injection molded mold dies fabricated in accordance with applicants' invention will also outlast the metal dies produced in accordance with Amaya et al in applications such as die casting of metals, due to the substantially higher chemical resistance of ceramic materials over that of tool steels.

2. Applicants' invention provides a novel means for reducing the time and cost of manufacturing of molds and mold inserts by obviating any secondary operations and the associated manufacturing costs.

Amaya et al recognize the importance and benefits of reducing the time of fabrication of the mold inserts, and achieve this criterion through the near-net shape capability of the metal injection molding process.

US 5,976,457, Col. 10, lines 47-50

Closely tied in to this is the time of fabrication, which is comparable to the time used to produce the plastic tools as well as the dimensional precision obtained with this process.

Yet, despite the shorter time of fabrication proffered by the injection molding process, Amaya et al's mastery of their process is insufficient to prevent the need for various secondary operations and heat treating on mold inserts produced according to their invention.

US 5,976,457, Col. 10, lines 31-34

*This cavity die **50** will undergo a number of secondary operations that will include heat treating to harden the metal, and grinding and polishing, to assure a tight fit in the die pocket **52**.*

US 5,976,457, Col. 10, lines 39-40

*The core die **60** will require the same secondary operations as the cavity die **50**.*

One of the major reasons for Amaya et al's admitted lack of dimensional control over their process, and the ensuing inevitable need for secondary machining, is their declared endeavor to use coarse metal powders in their molding feedstock.

Metal injection molding feedstocks must possess the proper rheology for molding. For this reason, fine spherical metal powders produced by gas atomization are preferred to amorphous or acicular powders. The morphology and granulometry of the powders used by Amaya et al are typical of the metal injection molding industry.

US 5,976,457, Col. 6, lines 59-65

One example, would be to use M-4 high speed tool steel powders for the formulation. These are spherical gas atomized powders produced and sieved by Anval Corporation in Sweden to a particle size less than 30 microns, and mixed with a polymer/wax binder so that the premixed material has 94% by weight powder loading with the remaining 6% by weight being binder..

However, the finer the powder particle size the higher its specific surface area and, therefore its surface activity. High surface activity renders incorporation of the powder into the binder difficult. In order to achieve identical molding rheology, a metal injection molding feedstock based on a fine powder requires more binder than one based on a coarser powder. On the other hand, the shrinkage of metal injection molded parts upon sintering is directly proportional to the volume fraction of binder contained in the injection molding feedstock. A large shrinkage renders control over sintered dimensions

difficult. Hence, the smaller shrinkage associated with coarser powders have been an incentive for their use.

Another reason for the metal injection molding industry's endeavor to use the cheaper and more available coarser powders is their lower cost as compared to the finer gas atomized powders which usually consist of the undersize of expensive screening operations.

Amaya et al follow this trend of the industry and even lay claim to their ability to do so:

US 5,976,457, Col. 12, lines 28-30 (Amaya et al's claim **8**)

*The method of claim **6**, wherein powders coarser than the norm of -30 microns in size, are used to prepare the powder molding material.*

Coarse powders do not allow to achieve fine design detail in a finished injection molded precision product. Clearly, it would be impossible to achieve a 20 micron design feature like a wall or a boss using an injection molding feedstock made up of a dispersion of 30 micron sized powder in a binder.

Hence the use of coarse powders, whilst allowing a reduction in the cost of raw materials, carries with it poor surface finish and design detail and thus the need for secondary machining.

Amaya et al accept as normal and inevitable the need for extensive secondary machining in order to ensure the necessary tight fit of their mold inserts in the mold base pockets. Amaya et al's resignation to a philosophy of injection molding, of necessity followed by machining, is further reflected and corroborated by their admitted lack of precision in the fabrication of the core and cavity patterns for their mold inserts, viz.

US 5,976,457, Col 7, Lines 34-39

Because of the effect of the shrink factor described above, tolerance sloppiness on the pattern will be compounded with the resulting tolerance range of the processing itself. As a reference, the tolerance band of the solid modeling process should be set at a range of plus or minus 0.0625 mm from the nominal desired dimensions.

Amaya et al's admitted lax manufacturing tolerances on their core and cavity patterns can never result in dimensionally precise mold inserts. As a practical illustration, a plus or minus 0.0625mm tolerance range on a 5mm core or cavity dimension corresponds to a manufacturing tolerance capability of about 2.5% whereas the norm in state of the art metal injection molding is at least 0.3% and often less than 0.1%.

In summary, the inevitable post-sintering machining and hardening operations, which are part and parcel of Amaya et al's invention, translate into added costs and time of manufacture.

Furthermore, the need for secondary machining operations on each and every mold insert fabricated according to Amaya et al's invention renders their process at best uneconomical and at worst unsuitable for the production of interchangeable mold inserts intended for mass-production in multi-cavity molds located in different geographical locations.

These problems are overcome in the present invention since applicants' ceramic mold inserts are produced from injection molding feedstocks containing submicron sized ceramic particles, such as Alcoa's A-16SG reactive calcined alumina which has an average particle size of less than 0.5 microns, thus allowing to achieve the superior definition demanded by today's highly configured or microprecision components with

manufacturing tolerances well below 0.1%, thus obviating the need for any secondary machining.

3. Applicants' invention provides a novel means for reducing the cost of tooling and tool inserts through the use of cheaper raw materials.

A further aspect in the overall cost reduction of molds and mold inserts rendered possible by applicants' invention is the substitution of substantially cheaper ceramic materials for the tool steels used by Amaya et al.

Stainless steel and tool steel powders suitable for metal injection molding are currently sold at prices in the $25 to well over $50 per kg whereas the submicron sized reactive calcined alumina powders used in the instant invention sell at less than $3 per kg.

4. Amaya et al do not anticipate the use of ceramic materials, but instead dismiss these materials as unworkable, having failed to find a solution to a problem which is solved by applicants' invention.

Amaya et al are persons skilled in the art of metal and ceramic injection molding.

US 5,976,457, Abstract, lines 16-20

These molds or molding dies and mold components can be used as part of a rapid prototyping mold or as a permanent mold that can be used (to) produce parts made out of plastic, metal, ceramic or composite materials.

Furthermore, Amaya et al cannot have been ignorant of the many benefits springing from the use of ceramic materials for their mold inserts in lieu of the tool steels used in their invention.

Yet, nowhere in Amaya et al's specification is there the slightest allusion to the use of ceramic materials for their mold inserts. Amaya et al strictly limit the choice of materials used to fabricate their mold inserts to metals in general and tool steels such as M4 in particular. This restriction in the choice of materials for Amaya et al's mold inserts constitutes a serious limitation of the scope of application of their invention and a recognized problem for which Amaya et al have no solution.

Had Amaya et al. been able to anticipate the use of ceramic materials, they would certainly have included these materials in their claims. It is laudable that Amaya et al have been totally honest in purposely restricting the scope of their disclosure to the field of metals.

We must, therefore, conclude that Amaya et al. not only did not at any time anticipate the use of ceramic materials for their mold inserts, but were in fact utterly convinced that the use of these materials was unworkable using the art that was within their skills.

The novel physical features of applicants' claim 15 produce new and unexpected results and hence are unobvious and patentable over the cited references.

The Rejection of Claims 2 and 3 Under 35 U.S. C. § 103(a)

The last O.A. rejected dependent claims 2 and 3 under 35 USC § 103(a) on the grounds that these claims were unpatentable over Amaya et al and further in view of Ruhle (US 5,199,482) and Williamson et al (US 5,435,959) respectively.

But, in view of the foregoing discussions, applicants, now having overcome the rejection of their claim 1 under 35 U.S.C. 102, submit that their claims 2 and 3, now rewritten as

new claims 16 and 17 respectively, define patentability over these references and any combination thereof.

Conclusion

For all of the above reasons, applicants submit that the specification and claims are now in proper form and that the claims all define patentably over the prior art. Therefore they submit that this application is now in condition for allowance, which action they respectfully solicit.

Conditional Request For Constructive Assistance

Applicants have amended the claims of this application so that they are proper, definite and define novel subject matter which is also unobvious. If, for any reason this application is not believed to be in full condition for allowance, applicants respectfully request the constructive assistance of the Examiner pursuant to M.P.E.P. § 2173.02 and § 707.07(j) in order that the undersigned can place this application in allowable condition as soon as possible and without the need for further proceedings.

Very respectfully,

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April 30, 2002 --

Romain L. Billiet, Applicant